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EP 0433573 A2 WO 96/05582 A1 US 4972181 A
US 4138670 A

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(54) Mains powered alarm device with rechargeable battery backup

(57) A smoke or fire alarm system is supplied from the mains or from vanadium pentoxide lithium batteries BAT1-3 charged through regulator U2 and protected by diodes CR8-10. A variable resistor VR1 sets normal voltage about 10% above nominal battery voltage. A battery testing circuit 15 draws 10msec current pulses from the batteries every 40 seconds through an LED and a resistor. If the battery voltage falls below a preset level, an alarm is sounded. During testing, a diode 13 reduces the output voltage from regulator U2 to prevent current flow to the batteries through resistor R4.

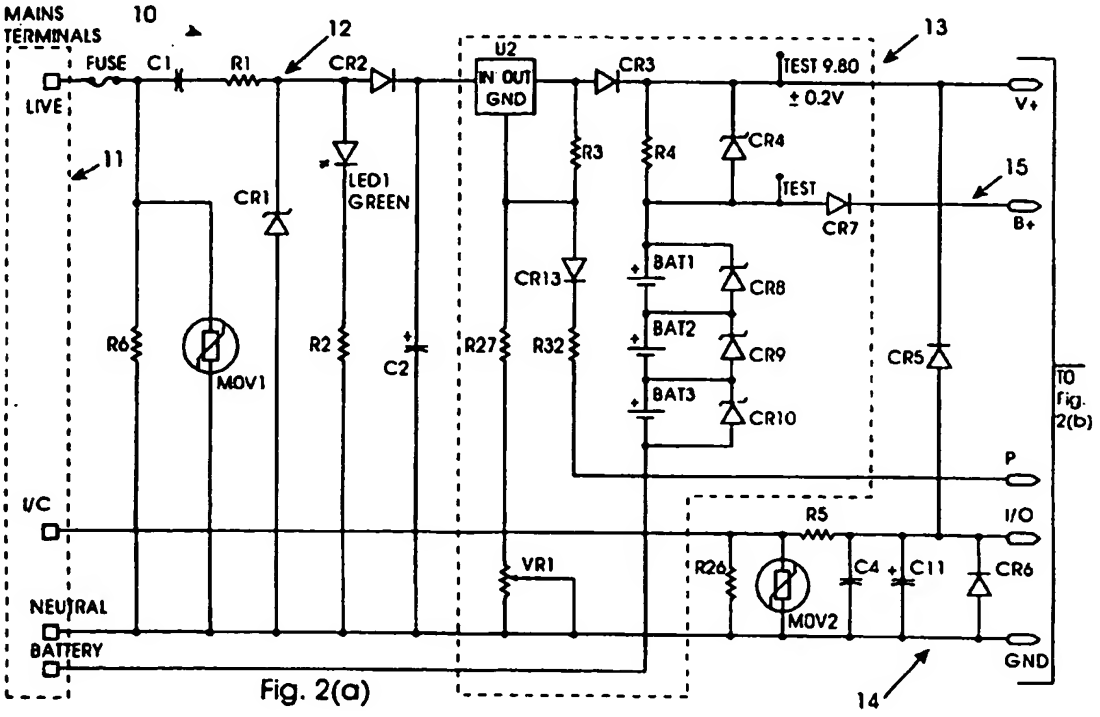

Fig. 2(a)

GB 2 312 343 A

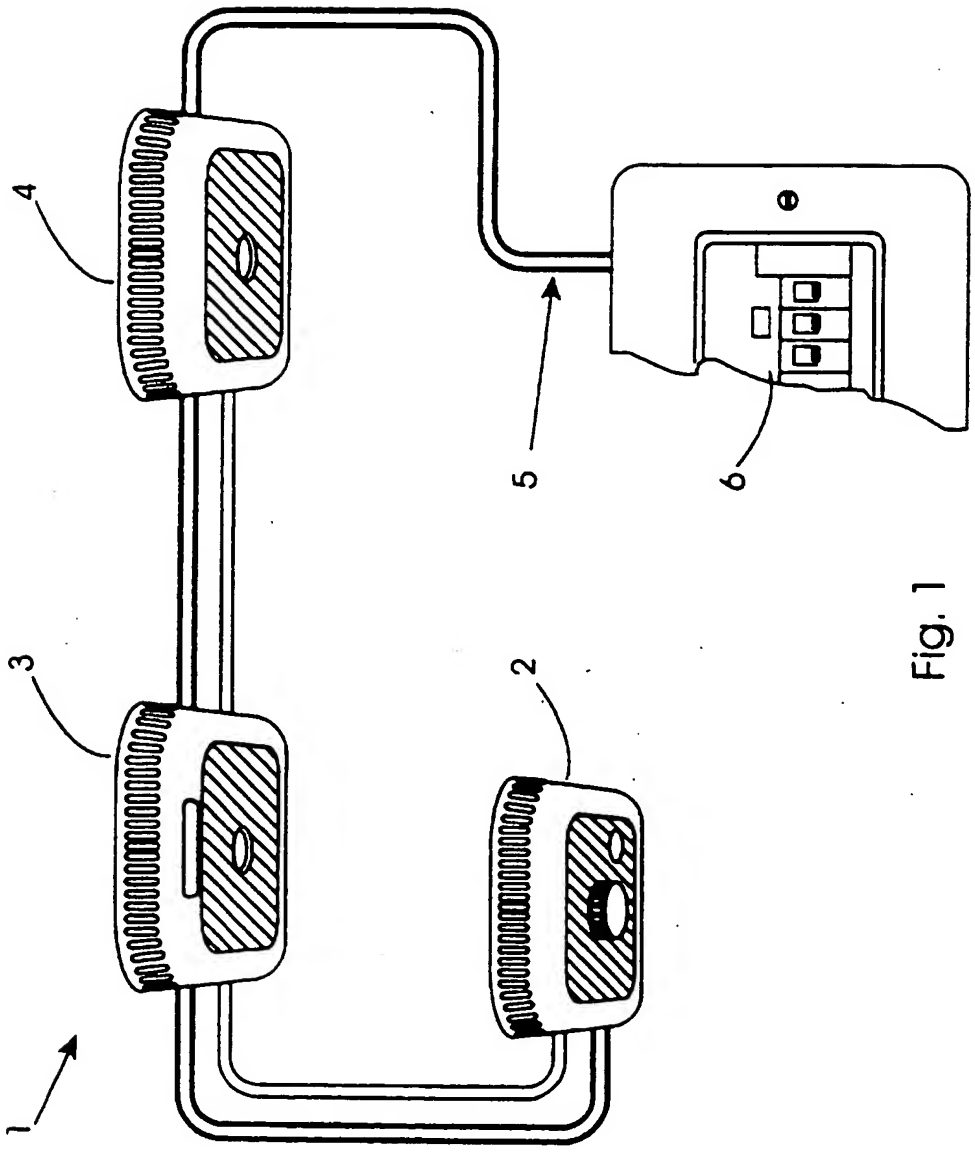

Fig. 1

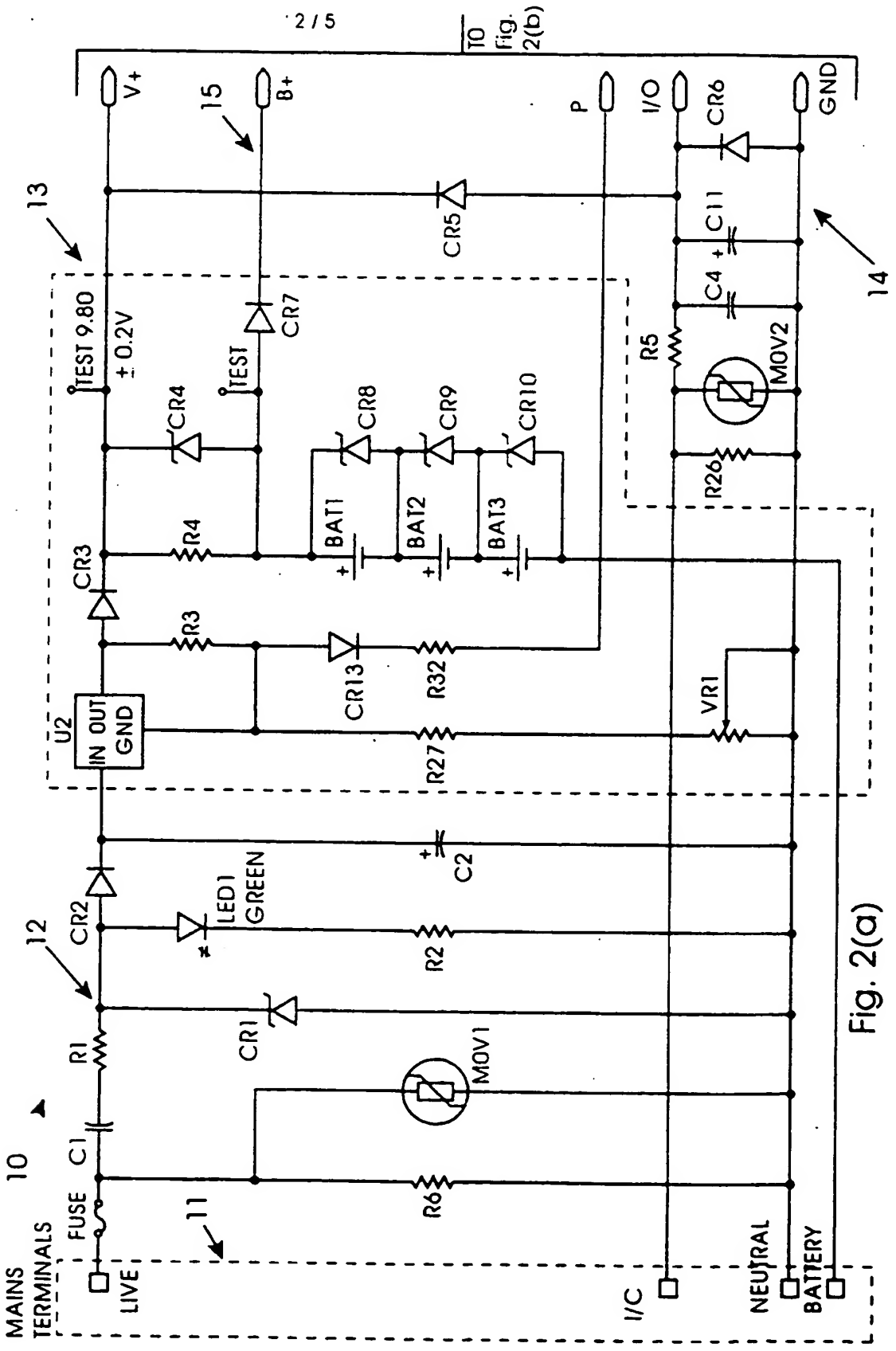
TO fig. 2(b)
V+
B+
P
I/O
GND
CR6
CR5
C11
C4
MOV2
R5
R26
TEST 9.80 ± 0.2V
ITEST
CR7
CR4
CR8
CR9
CR10
BAT1
BAT2
BAT3
R4
CR3
R3
CR13
R32
U2
IN OUT GND
R27
VR1
C2
LED1 GREEN
CR2
R2
CR1
MOV1
R1
C1
R6
FUSE
MAINS TERMINALS
LIVE
I/C
NEUTRAL
BATTERY
10
11
12
13
14
15

Fig. 2(a)

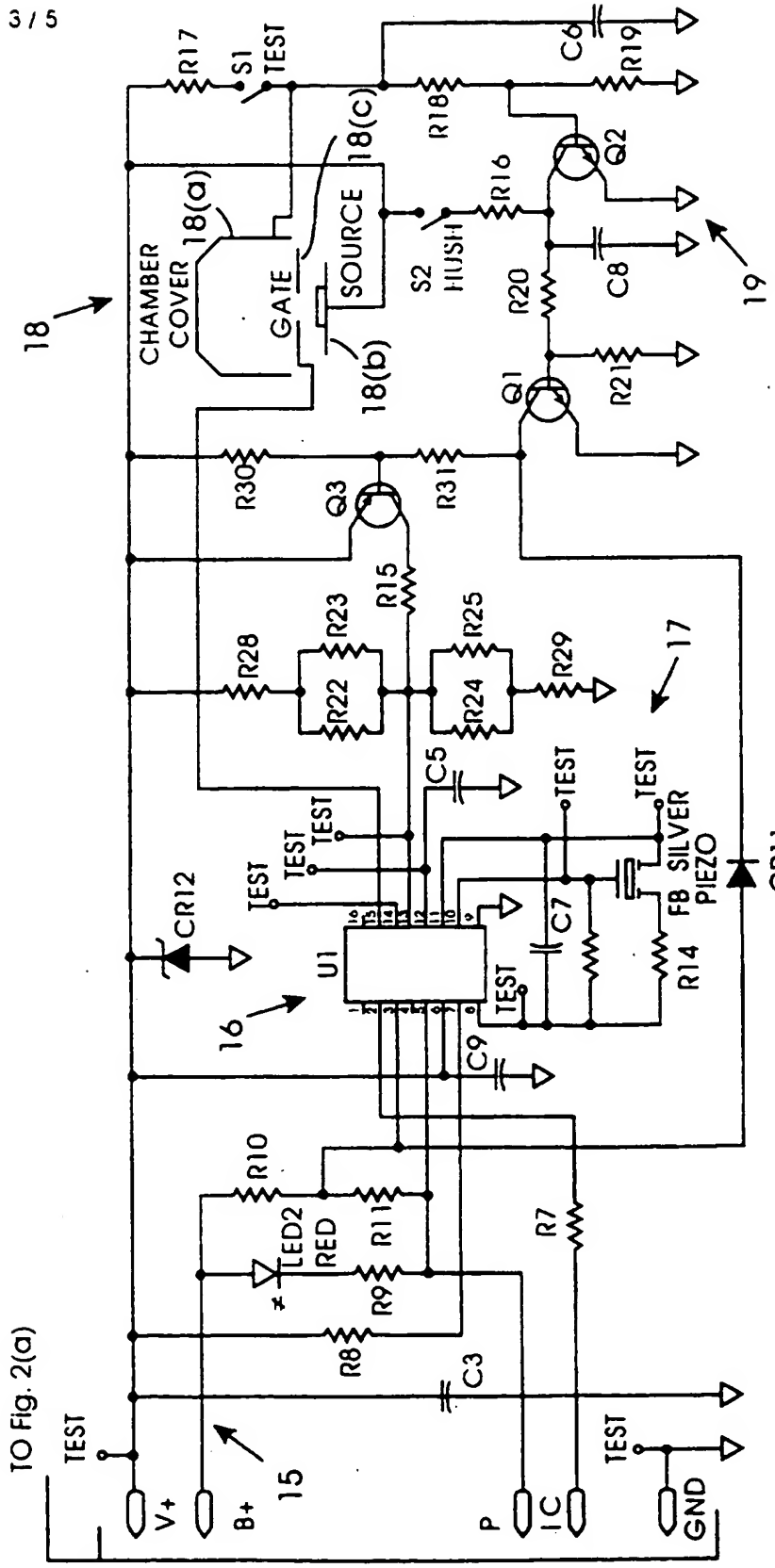
TO Fig. 2(a)
TEST
V+
B+
15
P
IC
TEST
GND
C3
R8
R10
R11
LED2
RED
R9
R7
C9
U1
16
CR12
TEST
TEST
TEST
C5
TEST
TEST
C7
R14
FB SILVER
PIEZO
CR11
R28
R23
R22
R15
R25
R24
R29
17
R30
Q3
R31
18
CHAMBER
COVER
18(a)
GATE
SOURCE
18(b)
18(c)
S1
TEST
R17
S2
HUSH
R16
R18
Q2
Q1
R20
R21
C6
R19
C8
19

Fig. 2(b)

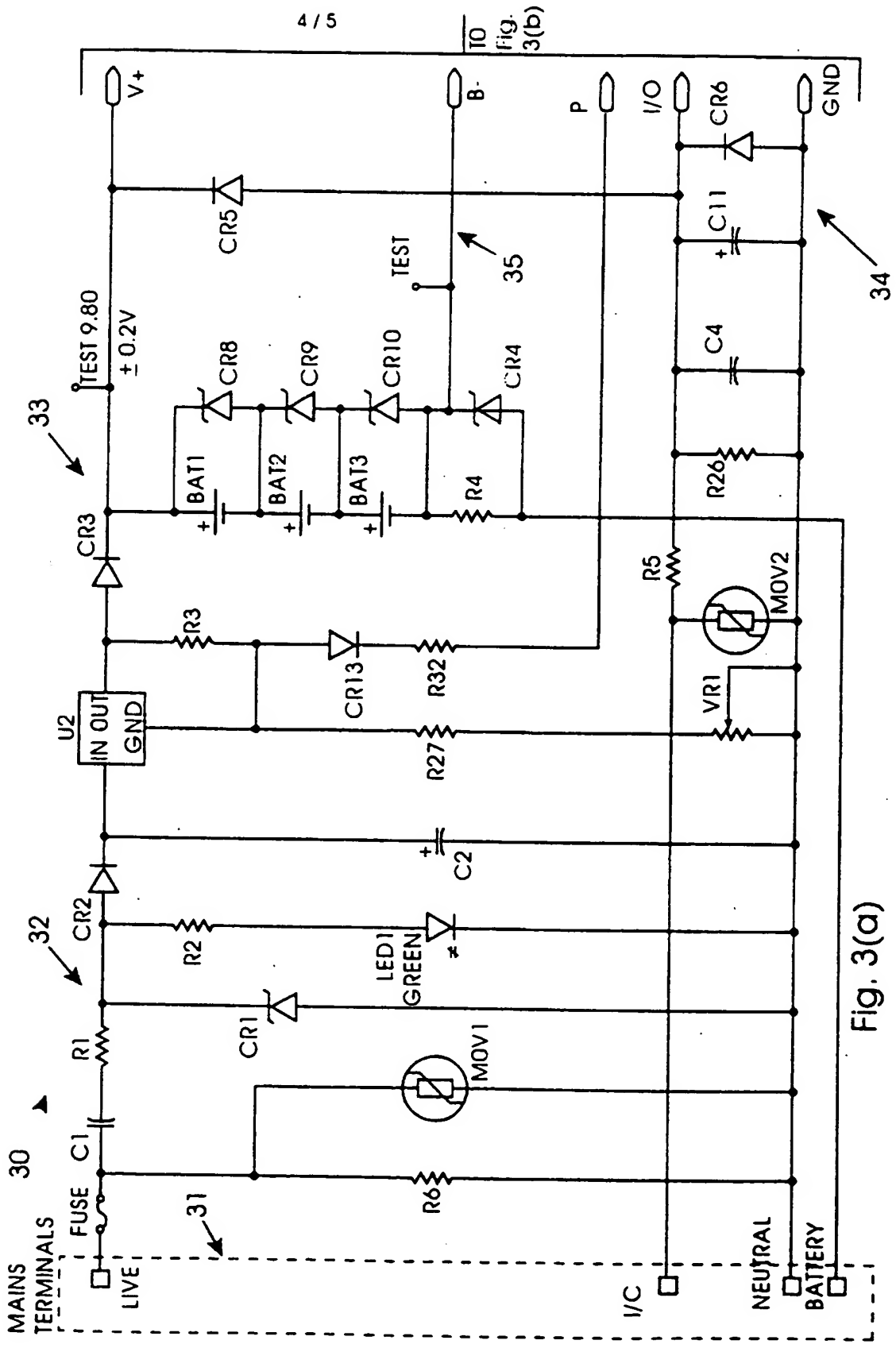
MAINS TERMINALS
LIVE
FUSE
C1
R1
CR1
MOV1
R6
CR2
R2
LED1 GREEN
C2
U2 IN OUT GND
R3
CR13
R32
R27
CR3
BAT1
BAT2
BAT3
R4
CR8
CR9
CR10
CR4
TEST 9.80 ± 0.2V
TEST
CR5
V+
B-
P
I/O
CR6
GND
C11
C4
R26
R5
MOV2
VR1
NEUTRAL
BATTERY
I/C
TO Fig. 3(b)
30
31
32
33
34
35

Fig. 3(a)

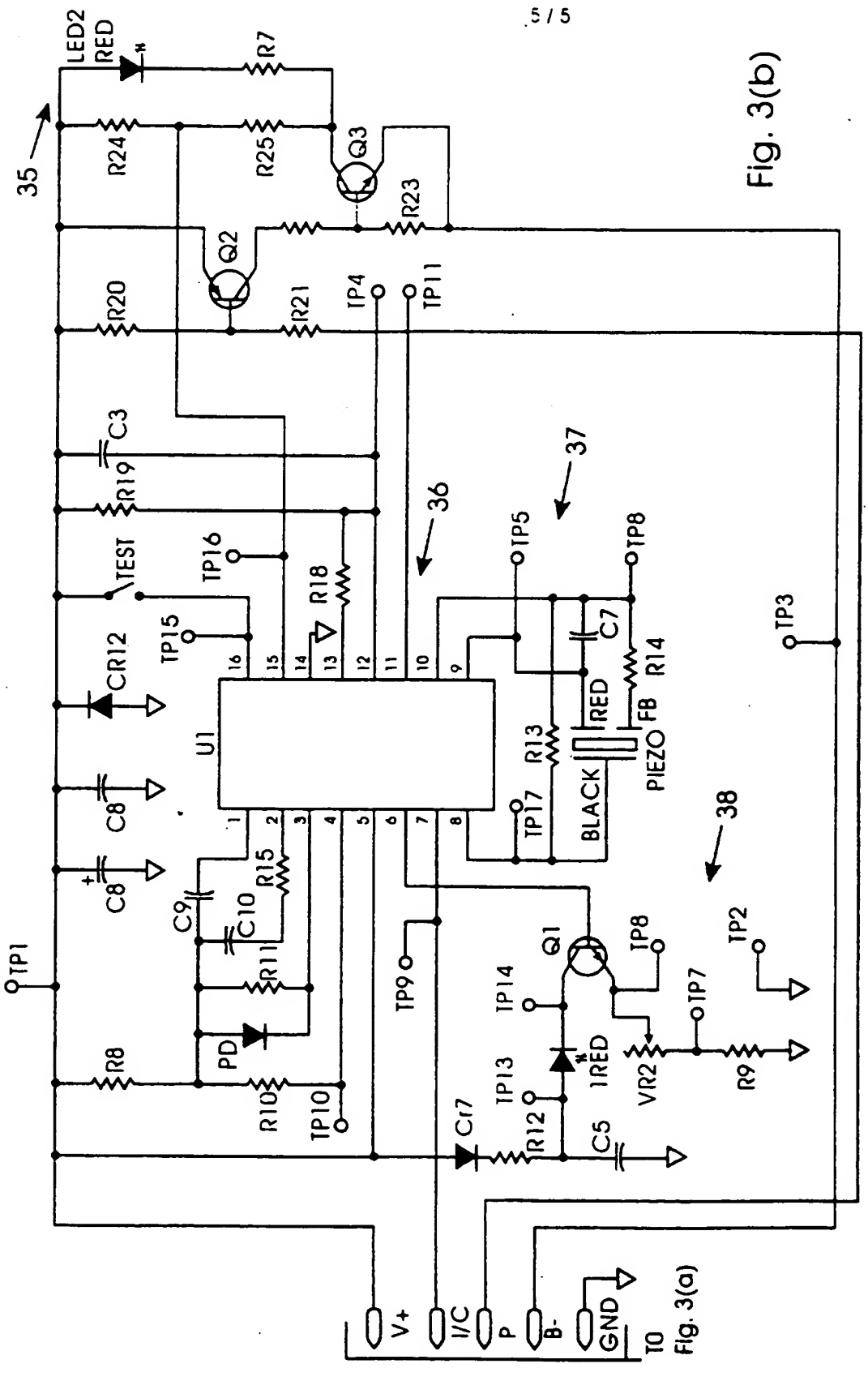
LED2
RED
R7
R24
R25
Q3
R23
35
Q2
R20
R21
TP4
TP11
C3
R19
TEST
TP16
R18
36
37
TP5
TP8
TP15
C7
R14
CR12
U1
RED
FB
TP3
R13
PIEZO
C8
TP17
BLACK
38
C8
R15
C9
C10
TP1
R11
Q1
TP8
TP2
TP9
TP14
TP7
PD
R8
IRED
VR2
R9
TP13
R10
TP10
CR7
R12
C5
V+
I/C
P
B-
GND
TO
Fig. 3(a)

Fig. 3(b)

"A mains powered alarm device
having a rechargeable battery backup"

The invention relates to an alarm device which is mains powered and has a rechargeable battery backup for emergency use. Such alarm devices are described in United States Patent Specification Nos. US 4,893,324 (Scown) and US 4,980,672 (Generation Two) and British Patent Specification No. GB 2,269,494 (Derbyshire Maid Limited).

It is an object of the invention to provide such an alarm device in which the rechargeable backup battery has a long life, preferably in excess of 10 years. Another object is to improve reliability in such alarm devices, to provide effective battery testing, and to minimise component costs.

According to the invention, there is provided an alarm device comprising a sealed housing, AC mains terminals, a DC rectifier connected between the mains terminals and DC rails, a rechargeable battery backup, a condition sensing means, a control means, and an output means, wherein:-

the rechargeable battery backup comprises at least one rechargeable battery connected across the DC rails and a parallel clamping diode to limit charging voltage;

the control means comprises a resistive charging circuit connected between a rail and the battery;

the control means comprises a battery testing circuit comprising means for drawing pulses at regular intervals from the battery backup, means for monitoring voltage level of the pulses and comparing with a pre-set reference value, and means for temporarily reducing rail voltage

during testing so that battery monitoring is similar with and without mains power present.

Preferably, the control means comprises a voltage regulator in a positive DC rail, and the battery testing circuit comprises means for reducing regulator output voltage level.

In one embodiment, the means for temporarily reducing rail voltage comprises a diode connected to prevent current flowing from the DC rails to the battery backup if the battery backup voltage is above a threshold level sufficient to maintain the control means in operation.

Preferably, the batteries are of the vanadium pentoxide lithium type.

In a further embodiment, each battery has a nominal capacity of approximately 50mAh.

In another embodiment, the battery testing circuit comprises means for drawing pulses through a diode and a resistor.

Preferably, the battery testing circuit comprises means for drawing the pulses through a light emitting diode to indicate satisfactory operation of the testing circuit.

In one embodiment, the control means comprises a ballast capacitor connected across the DC rails upstream of a regulator.

In another embodiment, the control means comprises a resistor setting a potential across the batteries which is approximately 10% higher than the nominal battery voltage output.

The condition sensing means may detect smoke, whereby the device is a smoke alarm device.

The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagrammatic view showing an alarm system incorporating three alarm devices of the invention;

Figs. 2(a) and 2(b) are together a circuit diagram of a control circuit of one alarm device; and

Figs. 3(a) and 3(b) are together a circuit diagram of the control circuit of an alternative alarm device of the invention.

Referring to the drawings, and initially to Fig. 1, there is shown a fire alarm system 1 comprising various alarm devices of the invention interconnected together and receiving power from the mains supply. The system 1 comprises a heat alarm 2 which responds to high temperature and is particularly suitable for use in kitchens, garages and other areas where a smoke alarm would given excessive nuisance alarms. Such an alarm is less sensitive than a smoke alarm and accordingly, it must always be used in conjunction with a smoke alarm for adequate early fire warning. The system 1 also comprises an ionisation smoke alarm 3 which is particularly effective for detecting the small smoke particles produced by fast flaming fires such as those which occur upon combustion of wood, paper and other similar materials. The system 1 also comprises an optical smoke alarm 4 which responds to all standard fires and is particularly

effective in detecting the large smoke particles produced by slow smouldering fires such as those which occur upon combustion of soft furnishings, PVC wiring, plastics foam, and other similar materials. The alarms 2, 3 and 4 are interconnected by a mains cable 5 which connects them to a consumer electrical mains panel 6 having circuit breakers and associated circuitry.

To ensure operation in the event of failure of the mains, each of the alarms 2, 3, and 4 has a rechargeable backup battery which is permanently connected and is not accessible to users because of the tamper-proof nature of the casings. The rechargeable batteries operate for the full working life of the alarm device, normally approximately 10 years.

Referring now to Figs. 2(a) and 2(b), a control circuit 10 for the ionisation smoke alarm 3 is now described. The circuit 10 comprises a mains terminal block 11 which includes a battery negative terminal shorted to a neutral terminal. It also includes an interconnection terminal I/C for interconnection of the alarms so that they all sound when one detects a smoke or heat condition.

The terminals 11 are connected to an input stage 12 having a safety fuse and a 1 W resistor R1 to limit in-rush currents. A capacitor C1, the resistor R1 and a zener diode CR1 reduce the mains voltage to 15 Volts. A metal oxide varistor MOV 1 is connected across the rails to suppress electrical transients. A green light emitting diode LED1 provides a continuous indication of presence of mains power. Diodes CR1 and CR2 provide half-bridge rectification at the input to a regulator U2 of a power supply 13 of the circuit 10.

The power supply 13 comprises a set of three vanadium pentoxide lithium rechargeable batteries BAT1, BAT2, and BAT3 connected in series between the neutral and the positive rails. The connection to the positive rail is through a resistor R4 which limits the charging current during normal operation. The charging potential of the set of batteries is maintained at approximately 10% higher than the total battery output of 9V, in this embodiment, 9.8V. This potential is set by a variable resistor VR1 between neutral and a resistive connection to the positive rail. It has been found that this charging potential is particularly effective at maintaining the batteries in an operative state with minimum discharge. Each of the batteries has a nominal voltage of 3.0V and a nominal capacity of 50 mAh. An important aspect of the power supply 13 is that each of the batteries has a diode CR8, CR9 or CR10 connected across it to limit the maximum voltage across each battery and prevent overcharging of any individual battery upon failure of another one. This provides for balanced charging in an extremely simple manner. It has been found that this arrangement helps to provide improved reliability. The 0-Volt battery side is connected to an external plug which is engageable with an external socket having a mains neutral terminal. Thus, the battery backup is disconnected until installation, upon which the socket and plug are engaged to connect in the battery backup. This is a simple way of ensuring that nuisance alarms do not arise in transit or storage before installation.

The control circuit 10 also comprises a voltage suppression circuit 14 mounted between neutral and the interconnect line I/C. This is particularly important at suppressing transients which may arise in the mains circuit between the alarms 2, 3 and 4.

The circuit 10 also comprises a battery testing circuit 15 which comprises a series connection of a diode CR7, a light emitting diode LED2 (red) and a resistor R9 which connect the positive terminal of the batteries to pin 5 of a controlling integrated circuit 16. The circuit 15 also comprises a potential divider R10/R11 which is tapped off to provide a voltage signal at pin 3 of the IC 16. The IC 16 is programmed to draw a pulse of 10 ms duration every 40 seconds through CR7, LED2 and R9. If the voltage at pin 3 falls below a set reference level within the IC 16, the IC 16 activates a horn circuit 17 to emit a short low-battery beep. The battery testing circuit 15 also includes a series connection of a diode CR13 and a resistor R32 between R3 and R9. This connection drops the regulator output voltage during the 10 ms pulse every 40 seconds to about 6.0V. This ensures that no current flows through R4 while the battery voltage is greater than 6.0V. Thus, the low-battery trip points are essentially the same with and without mains present. Further, by dropping the regulator to 6V it ensures that the unit operates satisfactorily (for example, does not reset or cancel alarms) even with a shorted battery as the IC 16 still sees at least 6.0V.

Without CR13 and R32, the circuit 15 would trip at 7.0V/0 ohms (impedance in series with the voltage supply) or 9.0V/500 ohms with no mains present. However, with mains present, while the circuit 15 would trip at 7.0V/0 ohms, the impedance would need to be several hundred ohms higher. Such a high impedance in series with the battery might result in the alarm sound output being insufficiently loud. It will be appreciated that CR13 and R32 are a particularly cost effective way of solving this problem. Not only are they less expensive than a series pass element, but they do not have the attendant problems

of providing a varying voltage drop, leading to a less precise charging voltage.

The remainder of the control circuit 10 comprises an ionisation sensing circuit 18 which comprises a chamber cover 18(a), source 18(b) and gate 18(c). The source 18(b) is maintained at approximately 9V, the cover 18(a) at approximately ground, and the electrode at approximately 3.5 V. For testing, the switch S1 is closed, thus discharging C8 which cancels a hush circuit 19. The cover 18(a) voltage rises to 3 Volts through R17/R18 and the potential of the electrode 18(c) rises to cause output of an alarm signal.

The hush circuit 19 operates upon closure of the switch S2 which causes C8 to charge, switching on the transistor Q1 to provide a low-battery beep to indicate that the alarm is in hush mode. The transistor Q3 is switched on causing the voltage level at the collector to rise to change the sensitivity of the IC 16 for a limited period of time, in this embodiment 10 minutes.

It has been found that the manner in which the batteries are connected provides for reliability over prolonged periods of time, particularly as a result of operation of the parallel diodes and the level of charging potential. The operation of the charge current-limiting resistor R4 and the protection components of the input stage 12 also operate to prevent damage to the batteries.

Referring now to Figs. 3(a) and 3(b), a control circuit 30 for the optical alarm 4 is illustrated. The circuit 30 has a mains terminal block 31 which is similar to the block, 11, an input stage 32 which is similar to the input stage 12, and a suppression circuit 34 which is similar to the circuit 14. Again, the potential across the batteries

BAT1, BAT2, and BAT3 is set by a variable resistor VR1 and the level is again 9.8 V - approximately 10% higher than the nominal output of the batteries. In this embodiment, a testing circuit 35 for the batteries is connected to the negative side of the batteries, and the charging current-limited resistor R4 is also connected to the negative side. The circuit 35 draws pulses upon an activation signal to the base of a transistor Q2 every 40 seconds for a duration of 10 ms. The pulses are drawn through Q3, R7 and LED2 to the positive rail. The voltage signal is tapped off between R20 and R21 from the positive rail. The components CR13 and R32 perform a function similar to that in the circuit 10 of Figs. 2(a) and 2(b). The circuit 30 also comprises an integrated circuit controller 36, a horn circuit 37, and an optical detecting circuit 38.

The invention is not limited to the embodiments hereinbefore described, but may be varied in construction and detail.

CLAIMS

1. An alarm device comprising a sealed housing, AC mains terminals, a DC rectifier connected between the mains terminals and DC rails, a rechargeable battery backup, a condition sensing means, a control means, and an output means, wherein:-

the rechargeable battery backup comprises at least one rechargeable battery connected across the DC rails and a parallel clamping diode to limit charging voltage;

the control means comprises a resistive charging circuit connected between a rail and the battery;

the control means comprises a battery testing circuit comprising means for drawing pulses at regular intervals from the battery backup, means for monitoring voltage level of the pulses and comparing with a pre-set reference value, and means for temporarily reducing rail voltage during testing so that battery monitoring is similar with and without mains power present.

2. An alarm device as claimed in claim 1 wherein the control means comprises a voltage regulator in a positive DC rail, and the battery testing circuit comprises means for reducing regulator output voltage level.

3. An alarm device as claimed in claims 1 or 2, wherein the means for temporarily reducing rail voltage comprises a diode connected to prevent current flowing from the DC rails to the battery backup if the battery backup voltage is above a threshold level

sufficient to maintain the control means in operation.

4. An alarm device as claimed in any preceding claim, wherein the batteries are of the vanadium pentoxide lithium type.

5. An alarm device as claimed in claim 4, wherein each battery has a nominal capacity of approximately 50mAh.

6. An alarm device as claimed in any preceding claim, wherein the battery testing circuit comprises means for drawing pulses through a diode and a resistor.

7. An alarm device as claimed in claim 6, wherein the battery testing circuit comprises means for drawing the pulses through a light emitting diode to indicate satisfactory operation of the testing circuit.

8. An alarm device as claimed in any preceding claim, wherein the control means comprises a ballast capacitor connected across the DC rails upstream of a regulator.

9. An alarm device as claimed in any preceding claim, wherein the control means comprises a resistor setting a potential across the batteries which is approximately 10% higher than the nominal battery voltage output.

10. An alarm device as claimed in any preceding claim wherein the condition sensing means comprises means for sensing smoke.

11. An alarm device substantially as hereinbefore described with reference to the drawings.

The Patent Office

11

Application No:	GB 9608135.1	**Examiner:**	David Brunt
Claims searched:	1-11	**Date of search:**	5 July 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G4N (NCSE), H2K (KDX, KSX)

Int Cl (Ed.6): G01R (31/36)

Other: Online: EDOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	EP 0433573 A2	(SCHEIDT) whole document	1,6,7,10
Y	WO 96/05582 A1	(GARRICK) whole document	1,6,7,10
Y	US 4972181	(FIENE) see column 2 lines 48-64 and column 5 lines 20-25	1,6,7,10
Y	US 4138670	(SCHNEIDER) see column 5 line 56 to column 7 line 14	1,6,7,10

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.